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ABSTRACT

Employment in nuclear- and nuclear energy-related activities in 1981 was examined and compared to that in previous years. Survey instruments were returned by 784 establishments. Total 1981 nuclear-related employment was estimated to be 249,500--a growth of 22,600 (10%) workers over the 1977 total. Government-owned, contractor-operated (GOCO) workers made up 36.9% of this total; the private work force made up 63.1%. Among all the nuclear-related workers, scientists comprised 5.1%; engineers, 15.3%; and technicans, 17.5%. The remaining 62.1% was composed of managers, skilled craft and clerical workers, and other support services. Research and development involvement had declined from 1977, with 60.4% of scientists and 27% of engineers currently involved. Nuclear employment was concentrated in the Middle Atlantic and Pacific regions. Most was in large establishments. The largest single industrial segment activity was weapons development (16.9% of total employment), followed by reactor operation and maintenance employment (16.7%). Total nuclear-related employment had grown at a 4.5% annual rate from 1968 through 1981. Virtually all of this growth was in the private sector. The regional distribution had remained fairly stable. (Appendixes include the survey of nonrespondents, estimation method and supplemental tables, and survey form.) (YLB)

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OCCUPATIONAL EMPLOYMENT IN NUCLEAR-RELATED ACTIVITIES, 1981

Prepared by

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ABSTRACT

This report describes 1981 employment in nuclear-related activities and compares it to previous years. Employment characteristics examined include detailed occupations of scientists, engineers, and technicians; worker involvement in research and development activities; employment by industrial segment (e.g., reactor operation and maintenance, weapons production, and commercial laboratory services); employment by establishment type (government-owned, contractor-operated [GOCO], private, and nonprofit); regional employment; and employment by establishment size.

Total 1981 nuclear-related employment is estimated to be 249,500--a growth of 22,600 workers over the 1977 total. GOCO workers make up 36.9 percent of this total. Among all the nuclear-related workers, scientists comprise 5.1 percent; engineers, 15.3 percent; and technicians, 17.5 percent; the remaining 62.1 percent is composed of managers, skilled craft and clerical workers, and other support services. Research and development involvement has declined from the 1977 survey results, with 60.4 percent of scientists and 27.0 percent of engineers currently involved in R&D. The largest single industrial segment activity is weapons development (16.9 percent of total employment), followed closely by reactor operation and maintenance employment (16.7 percent). There has been considerable change in the distribution of employment by industrial segment from 1977 to 1981; the reactor and reactor component design and manufacturing segment fell by over 9,700 workers while reactor operation and maintenance employment grew by over 24,000 workers.

CHAPTER 1
INTRODUCTION AND SURVEY DESCRIPTION

INTRODUCTION

This report examines 1981 occupational employment in nuclear- and nuclear energy-related activities. Four years have elapsed since the last survey of occupational employment in the nuclear field was conducted in 1977. Because the field is changing rapidly, issues concerning the demand for and supply of nuclear-related personnel, personnel training, and occupational changes in the industry are receiving considerable attention.[1] A descriptive profile of present levels of employment in the nuclear field and comparisons to nuclear employment in previous years are provided in this study.

SURVEY DESCRIPTION

The 1981 employment data used in this report were collected by Oak Ridge Associated Universities in cooperation with the Institute of Nuclear Power Operations (INPO). A survey of occupational employment in nuclear- and nuclear energy-related activities (hereafter referred to as Form ERDA-601 or the Bureau of Labor Statistics [BLS], U.S. Department of Labor, defined field) queried establishments that are engaged wholly or partially in nuclear-related activities and are, therefore, competing for trained personnel with the nuclear power industry. An establishment is, in most cases, at a single physical location and is either a private sector firm or a government-owned, contractor-operated (GOCO) facility.

Excluded from the ERDA-601 survey are personnel employed in federal government agencies, the military, state and local governments, medical institutions, uranium mining, construction, and universities. The ERDA-601 data reported here have been supplemented by other sources to cover federal government agencies, state and local governments, and uranium mining (see Appendix B). Nuclear-related construction employment data are covered by the Construction Labor Demand System of the U.S. Department of Labor. Utilities, which were covered by previous ERDA-601 surveys, were surveyed separately by INPO, and these data are included here.

Previous employment data were collected by surveys of nuclear-related employment annually from 1960 through 1970 and biannually from 1971 through 1977 by the Bureau of Labor Statistics of the U.S. Department of Labor under contract with the U.S. Department of Energy (and its predecessor agencies).[2] The types of establishments included in the survey universe and the survey questions have not changed significantly since the 1968 survey, thus permitting reliable comparisons.[3]

The survey queried each establishment about the portion of their work force that is nuclear related with detailed information requested for engineer, scientist, technician, and reactor-operator occupations. The establishment responses were then aggregated by size (number of employees), industrial segment, GOCO or private employment, geographic region, and individual occupational group. (See Appendix C for a copy of Form ERDA-601. Definitions of nuclear-related activities, industrial segments, and occupations are given on the form.) Data are also available on the number of scientists and engineers who spend 50 percent or more of their time in nuclear-related research or development. The utilities responded to surveys requesting information for both onsite employment specific to a power plant and offsite support and design personnel. The occupational and industrial segment definitions used in the INPO survey are identical to the ERDA-601 survey, allowing the two data sets to be combined.[4]

SURVEY MAILING AND FOLLOW-UP

Table 1-1 outlines the response to the 1981 Form ERDA-601 survey. The universe was developed by ORAU using past ERDA-601 mailing lists, the 1981 *Nuclear News Buyer's Guide*,[5] and other sources. The total ERDA-601 mailing universe included 1,912 establishments; a total of 1,321 have returned forms with 643 in-scope responses (i.e., engaged in nuclear-related activities) and 604 out-of-scope responses (not engaged in nuclear-related activities). In addition, all INPO utilities have returned in-scope survey forms to INPO for 141 establishments (86 onsite establishments and 55 offsite establishments), bringing the total universe to 2,053 and the total returned inscope to 784. The remaining establishments are categorized as out of business, returned to sender, or refusal. No information concerning establishment status was received from 591 establishments who are thus classified as nonrespondents.[6]

TABLE 1-1. SURVEY RETURNS: 1977 AND 1981

	1977		1981		
Total universe		1,898			2,053[a]
Returned, in-scope					
Private	853		587		
GOCO	57		42		
Nonprofit	21		14		
Utilities[b]			141		
Total	931	931	784	784	
Out-of-scope	377		604		
Refusal	4		17		
Out of business or returned to sender	107		57		
Total	488	488	678	678	
Total returned		1,419		1,462	1,462
Nonresponse		479			591

[a]Includes 141 utility establishments; all were returned in-scope.

[b]Utilities are included in private in 1977.

NOTE: In 1977 all establishments in the universe were mailed Form ERDA-601. In 1981 utilities were surveyed separately by INPO.

In 1977, survey forms were mailed to 1,898 establishments with 931 returning in-scope responses (874 private and 57 GOCO) and 377 returning out-of-scope responses. Table 1-1 tablulates the number of forms returned in 1977 and in 1981. The 1977 return rate (75%) is only slightly higher than the 1981 return rate (71%). However, in 1977 a larger portion of the establishments returning forms were in-scope (66%) than in 1981 (54%).

Excluding utilities, the 1981 ERDA-601 survey underwent three mailings over a five-month period. In addition, 52 nonresponding establishments that reported more than 100 employees in the nuclear field in 1977 were then contacted by telephone and sent a fourth survey form. Despite the above efforts, 591 of the original 1,912 establishments (30.9%) did not respond to the survey. In order to determine the extent of nuclear-related employment among the nonrespondents,

100 were surveyed by telephone. The difference in proportion of nonresponding establishments that are in-scope (56%) and the difference in establishment size were not statistically significant. The nonrespondents did, however, have a statistically significant difference in industrial segment distribution with a large number appearing in the miscellaneous segment. (See Appendix A--Survey of Nonrespondents.)

NOTES

1. See for example John F. Clarke, *A Study of the Adequacy of Personnel for the U.S. Nuclear Program* (Washington, D.C.: U.S. Department of Energy, 1982); Jon Payne, "Nuclear Employment: More People Needed" *Nuclear News* 24 (November 1981), p. 51; and Nuclear Manpower Study Committee, *Personnel Supply and Demand Issues in the Nuclear Power Industry* (Washington, D.C.: U.S. Department of Energy, 1982). The INPO survey was prompted by a shortage of qualified personnel in nuclear power utilities, and data and results are contained in Institute for Nuclear Power Operations, *A Survey of Occupational Employment and Training in the Nuclear Power Industry* (Atlanta, Georgia: Institute for Nuclear Power Operations, 1982). Recent legislation (P.L. 96-567) contains provisions to identify the aptitudes, training, and manning levels for reliable reactor operation and to study the sufficiency of effort to provide trained manpower for reactor operation and other fuel-cycle positions.

2. From 1960 through 1973 the survey was sponsored by the Atomic Energy Commission. In 1975 the survey was sponsored by the Energy Research and Development Administration, and the 1977 and 1981 surveys were sponsored by the Department of Energy.

3. For detailed data on earlier years, see Joe G. Baker, *An Examination of Employment in the Atomic Energy Field*, ORAU-139 (Oak Ridge, Tennessee: Oak Ridge Associated Universities, 1978); and Larry M. Blair, "Occupational Employment Trends in Selected Nuclear Industry Segments in the United States," IAEA-SM-238/21, paper presented at the International Symposium of the International Atomic Energy Agency, Saclay, France, April 1979 (available from Oak Ridge Associated Universities, Oak Ridge, Tennessee).

4. For a description of the INPO data and survey, see Institute for Nuclear Power Operations, *A Survey of Occupational Employment.*

5. American Nuclear Society, *Nuclear News Buyer's Guide*, vol. 24, no. 4 (Mid-March), 1981.

6. Among the nonrespondents were two nuclear navy shipbuilding facilities. However, estimates for these facilities are included in the inflated totals in this report. In 1977 these two facilities indicated they had 3318 total nuclear-related employees. A third facility did not respond in 1977 and has since phased out its nuclear-related work and was therefore not included in the 1981 survey.

CHAPTER 2
1981 NUCLEAR-RELATED EMPLOYMENT

INTRODUCTION

The employment tabulations presented in this section describe the BLS-defined nuclear energy field in 1981. The main sources of data for these tabulations are the ERDA-601 survey and the INPO survey, described in the last chapter. In addition, these data were supplemented by both unpublished and published sources as footnoted.

All of the following tables and charts are based upon a subset of the estimated total 1981 nuclear-related employment universe. For example, the percent of the estimated total nuclear-related employment for which detailed occupational data are available is approximately 71 percent. This subset of 71 percent was used to estimate the occupational distribution of the total. The reader is cautioned to note table footnotes to determine the subset size from which the data presented in a given table are estimated. A discussion of the estimation method is in Appendix B.

TOTAL 1981 NUCLEAR-RELATED EMPLOYMENT

Total estimated 1981 nuclear-related employment was 249,533--a growth in total employment of 22,579 (10 percent) over the last estimate of 226,954 in 1977. As shown in the pie charts in Figure 1, this total was split into 92,012 government-owned, contractor-operated (GOCO) workers (36.9 percent) and a private work force of 157,521 (63.1 percent). This is a growth in the share of private employment since 1977, continuing a trend that started in the 1960s.

The pie charts in Figure 1 also detail employment shares by occupational clusters. The GOCO sector, with its research orientation, has a slightly higher percentage of scientists than the private sector. Both sectors have approximately the same percentage of workers in the "other" category. In 1981, 20.5 percent of total nuclear-related employment was composed of scientists and engineers compared to only 2 percent of the total U.S. work force.[1]

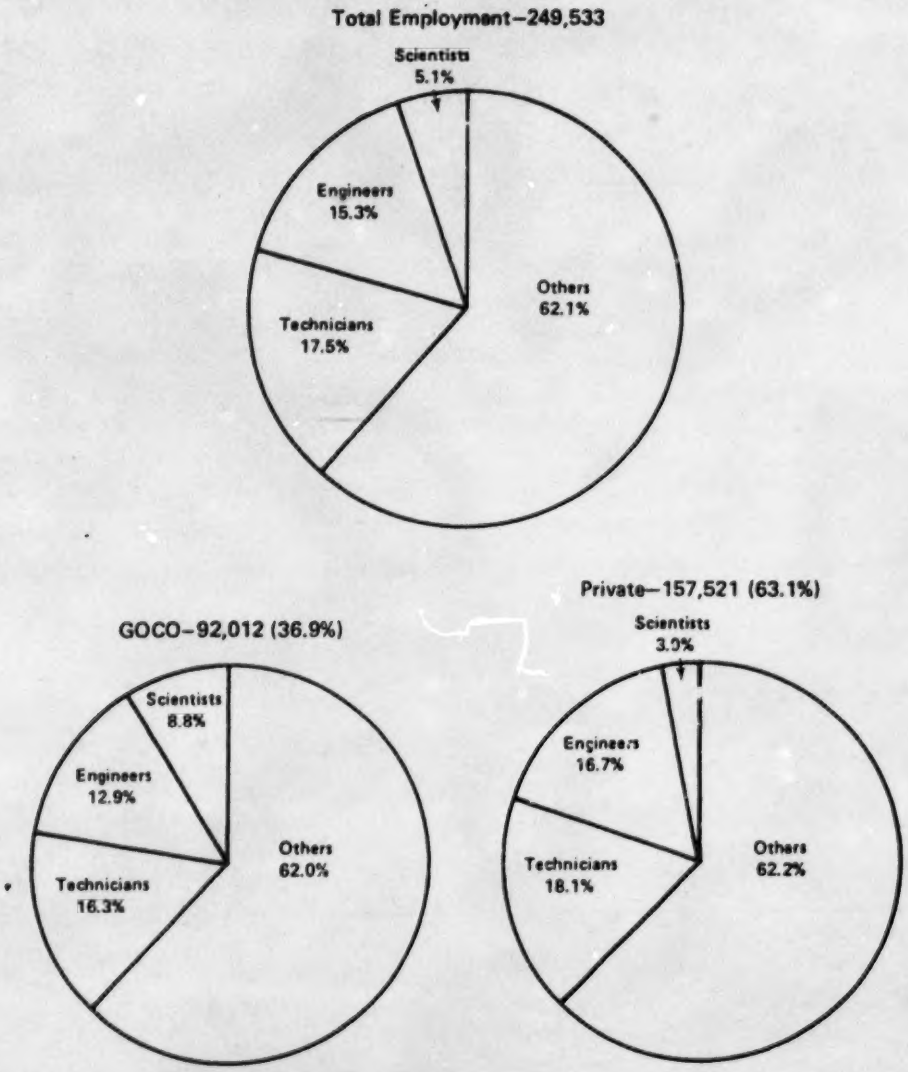

Figure 1. Total 1981 Nuclear-Related Employment

NOTE: Occupational data based on 71 percent of the estimated total nuclear-related employment universe.

Source: ERDA-601, INPO.

Engineers

Figure 2 details the specific engineering fields and portion of nuclear-related engineers involved in research and development in 1981. Of the estimated total of 38,167 nuclear-related engineers in 1981, mechanical engineers made up the largest share (29.1 percent), while metallurgical was the smallest (2.1). Of all engineers, approximately 27 percent were engaged in nuclear-related R&D. Metallurgical engineers had the highest portion in R&D; civil engineers, the lowest.

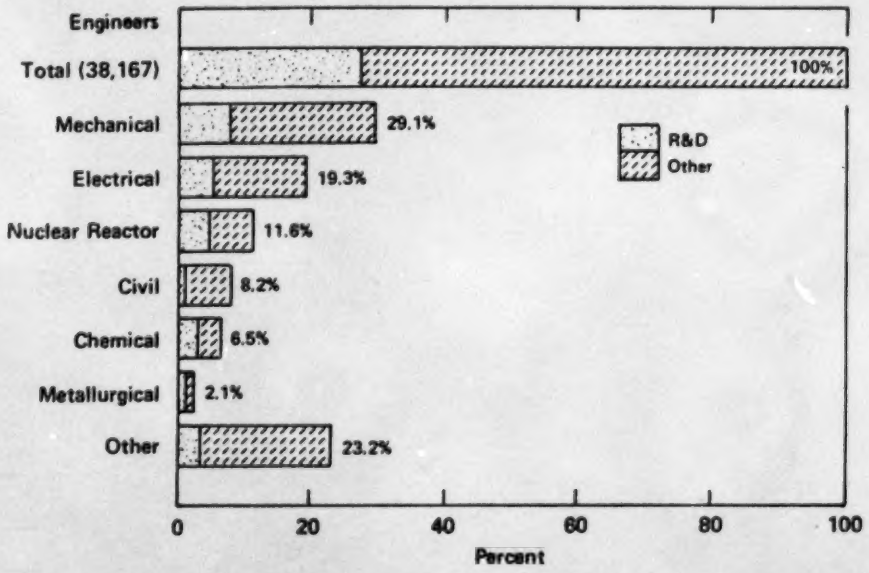

Figure 2. Engineering Fields by Research and Development, 1981

NOTE: Occupational data based on 71 percent of estimated total nuclear-related employment universe.

Source: ERDA-601, INPO.

Scientists

Figure 3 details the estimated 1981 total of 12,900 nuclear-related scientists by life scientists, mathematicians, and physical scientists. Almost two-thirds (65.0 percent) of total nuclear-related scientists were in the physical science group. Approximately 60 percent of all nuclear-related scientists were engaged in R&D, compared to 27 percent of the engineers.

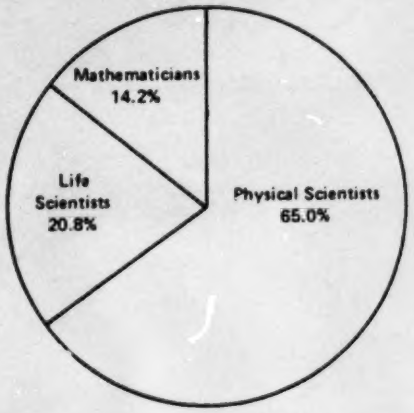

Figure 3. Distribution of Nuclear-Related Scientists, 1981

NOTE: Occupational data based on 71 percent of estimated total nuclear-related employment universe.

Source: ERDA-601, INPO.

Figure 4 details the specific fields within the physical science group by portion engaged in R&D. Physicists made up the largest portion of physical scientists (39.4 percent); geologists/geophysicists, the smallest (5.8 percent). Over 69 percent of all nuclear-related physical scientists were engaged in R&D; virtually all metallurgists were. Figure 5 details life science fields and life science involvement in R&D. Biologists made up the largest portion of life scientists (45.7 percent); medical scientists, the smallest (6.3 percent). Less than half of all nuclear-related life scientists were involved in R&D, although 69.8 percent of the biologists were. The research and development portion of all nuclear-related mathematicians was 40.0 percent.

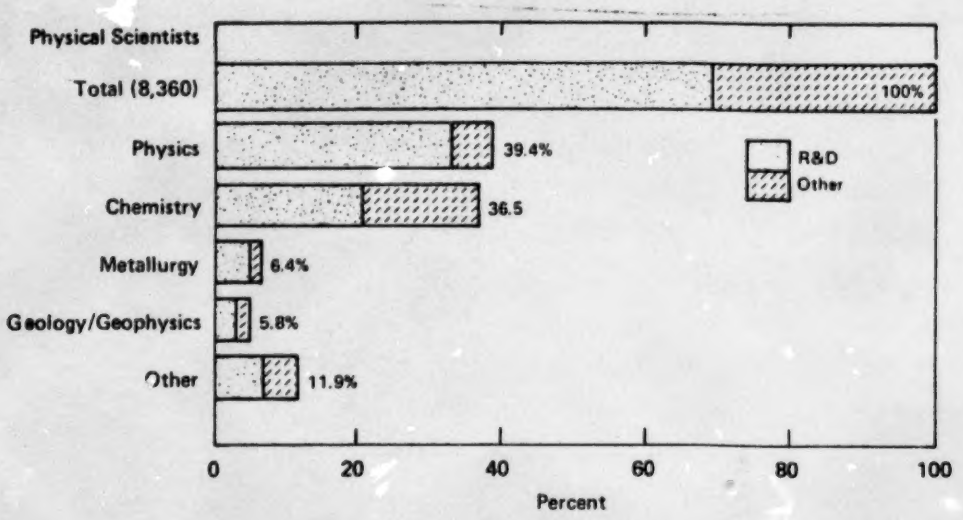

Figure 4. Physical Science Fields by Research and Development Shares, 1981

NOTE: Occupational data based on 71 percent of estimated total nuclear-related employment universe.

Source: ERDA-601, INPO.

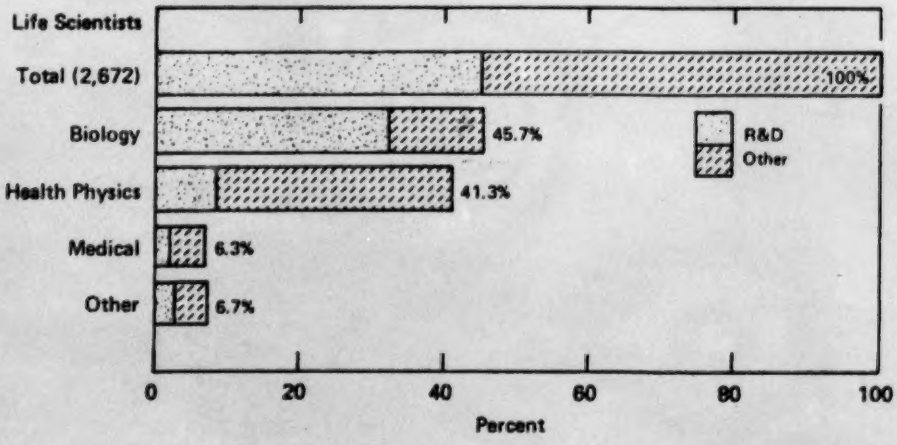

Figure 5. Life Science Fields by Research and Development Shares, 1981

NOTE: Occupational data based on 71 percent of estimated total nuclear-related employment universe.

Source: ERDA-601, INPO.

Regional Employment

Figure 6 details the percentage distribution of nuclear-related employment by region. The two regions with the most nuclear-related employment are the Middle Atlantic and Pacific. The Pacific region contains several large GOCOs that account for its large share.

The table in Figure 6 also shows the number of nuclear-related workers for every 1000 total workers in a given region. Nationwide, 2.3 workers per 1000 were nuclear-related in 1981.[2] This ranged from a high of 5.7 nuclear-related workers per 1000 in the Mountain region to a low of 1.1 nuclear-related workers per 1000 in the West South Central region. These figures exclude nuclear employment that was estimated.

	Region	1981 Employment	Percent	Nuclear-Related Workers per 1000 Total Workers in Region
I	New England	13,042	6.2	4.6
II	Middle Atlantic	37,258	17.8	2.5
III	East North Central	23,759	11.4	1.4
IV	West North Central	9,459	4.5	1.4
V	South Atlantic	26,451	12.6	1.9
VI	East South Central	23,651	11.3	4.7
VII	West South Central	10,430	5.0	1.1
VIII	Mountain	25,824	12.3	5.7
IX	Pacific	39,456	18.8	3.0
	Total U.S.	209,330	99.9	2.3

Figure 6. 1981 Nuclear-Related Employment by Region

NOTE: Excludes 40,203 employees that were not distributed by region because of lack of data.

Source: ERDA-601, INPO.

Employment by Establishment Size

Figure 7 gives the distribution of nuclear-related employment by establishment size. The industry is dominated by large establishments; 61.7 percent of total nuclear-related employment is in establishments of 1000 or more workers. This compares to 14.7 percent of total U.S. employment in establishments of 1000 workers or more. Only 7 percent of total nuclear-related employment is in firms employing fewer than 100 workers, compared to 54.1 percent of total U.S. employment.[3]

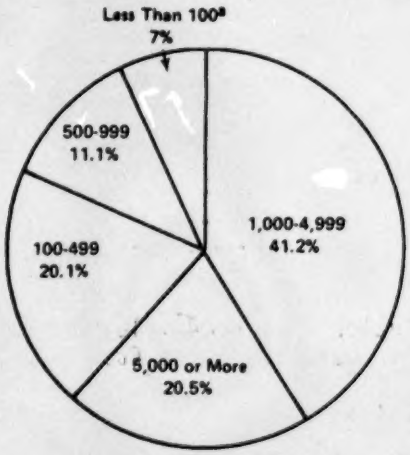

Figure 7. Distribution of Employment by Establishment Size, 1981

[a]Includes 1-9 employees (0.4 percent), 10-49 employees (3.0 percent), and 50-99 employees (3.6 percent).

NOTE: Data based on 84 percent of the estimated total nuclear-related employment universe.

Source: ERDA-601, INPO.

Employment by Industrial Segment

Each establishment responding to the ERDA-601 survey was asked to allocate its nuclear-related employment among 21 different industrial segments (see Section 6 of the form in Appendix C). Figures 8 through 11 detail private and GOCO employment allocated to each establishment's primary industrial segment (i.e., all of a given establishment's employment is classified in the one industrial segment employing the largest percentage of nuclear-related workers even though the establishment may be involved in more than one industrial segment). Of the total estimated nuclear employment universe of 249,533,

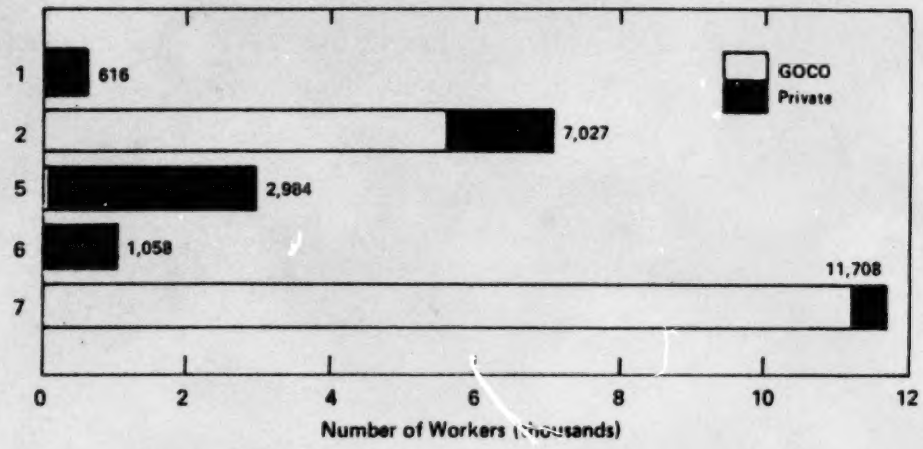

Figure 8. Nuclear-Related Employment in Industrial Segments Related to the Fuel Cycle, 1981

Industrial Segment Definitions

1 URANIUM MILLING: Reduction of uranium ores to concentrates. Excludes mining.

2 PROCESSING AND ENRICHMENT OF REACTOR FUEL MATERIALS: Refining of reactor fuel concentrates and conversion of refined fuel concentrates and recovered U-235/U-238 to uranium hexafluoride, enrichment of these fuel materials in the isotope U-235, followed by conversion to oxides, carbides, or other fuel compositions.

5 FUEL FABRICATION: Production of fuel forms (pellets, coated particles, etc.), and encapsulation of fuel forms in fuel assemblies.

6 TRANSPORTATION OF NUCLEAR MATERIALS: Packaging and interfacility transportation of special nuclear materials, fabricated fuel assemblies, irradiated fuel assemblies, and other radioactive materials.

7 CHEMICAL REPROCESSING AND DISPOSAL OF IRRADIATED MATERIALS: Separation and recovery of fertile and fissile fuel materials, and of by-product materials. Includes purification, concentration, and packaging of fuel and by-product materials; storage and solidification of high-level wastes; collection, packaging, and disposal of low-level wastes.

NOTE: Segment data based on 94.5 percent of the estimated total nuclear-related employment universe.

Source: ERDA-601, INPO.

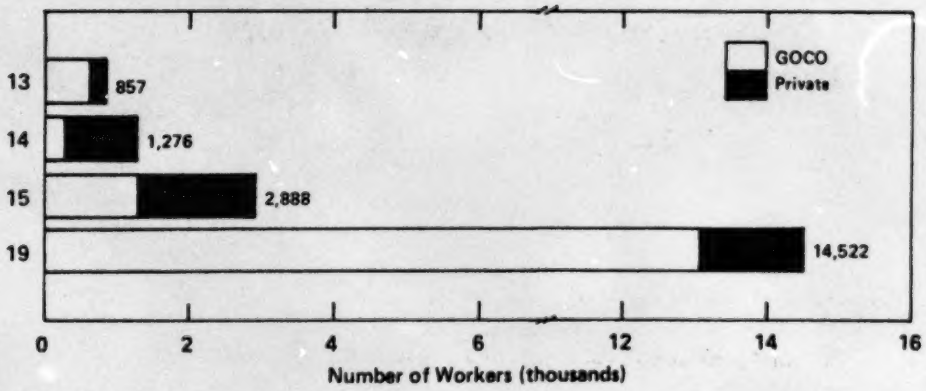

Figure 9. Nuclear-Related Employment in Industrial Segments Involved in Research, 1981

Industrial Segment Definitions

13 ENVIRONMENTAL AND ECOLOGICAL RESEARCH AND EVALUATION: Activities to preserve, improve, or restore the natural environmental and ecological balance. Types of activities covered are thermal effects and effects of irradiation on plants, animals, and marine life.

14 BIOLOGY AND MEDICAL RESEARCH: Research on the interaction of radiation with biological systems; use of radiation and radioisotopes in diagnosis and treatment of illnesses; study of effects of low-level radiation and ingestion of toxic and radioactive materials on biological systems.

15 REACTOR RESEARCH, DEVELOPMENT, AND EVALUATION: Activities relating to research, development, and demonstration of new fission reactor systems, components, fuels, moderators, etc. Includes development, conduct, evaluation, and analysis of reactor safety tests.

19 RESEARCH AND DEVELOPMENT IN NUCLEAR ENERGY: Investigations directed toward the development of new or fuller scientific knowledge of the subject. It also covers systematic application of scientific knowledge directed toward the creation of new or substantially improved processes, procedures, techniques, etc. It excludes research and development reported under segments 12, 13, 14, and 15, which are to be reported separately.

NOTE: Segment data based on 94.5 percent of the estimated total nuclear-related employment universe.

Source: ERDA-601, INPO.

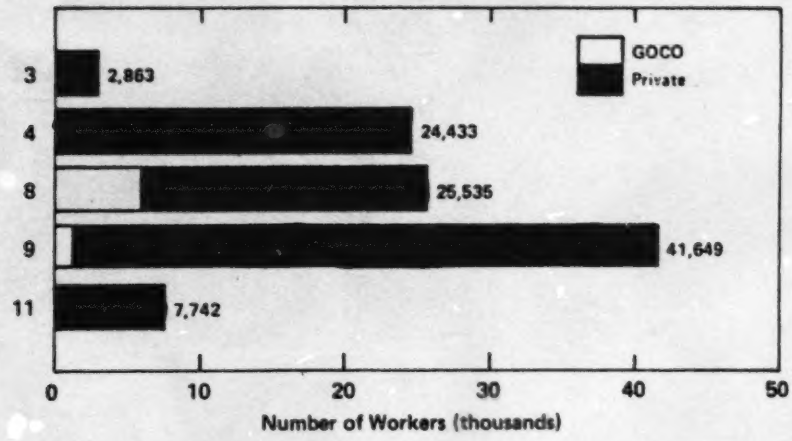

Figure 10. Nuclear-Related Employment in Industrial Segments Involved in Design, Manufacture, and Operation of Nuclear Reactors, Reactor Components, and Reactor Facilities, 1981

Industrial Segment Definitions

3 PRODUCTION OF SPECIAL MATERIALS FOR USE IN REACTORS: Preparation and treatment of core structural and cladding materials such as zirconium, control rod materials such as hafnium and boron, and moderators such as heavy water and graphite.

4 REACTOR AND REACTOR COMPONENT DESIGN AND MANUFACTURING: The design and/or manufacture of nuclear reactors and reactor components, including control rods and drives for power, test, and research purposes and missile and space applications. Includes the assembly, testing, and disassembly of reactors and the testing of materials for reactor use.

8 DESIGN AND ENGINEERING OF NUCLEAR FACILITIES: Design and engineering of all nuclear facilities with the exception of those included in segments 4 (reactor and reactor components), 5 (fuel fabrication), 11 (nuclear instruments, gauges, and control devices), and 12 (accelerators). Excludes persons working onsite in facility construction.

9 NUCLEAR REACTOR OPERATION AND MAINTENANCE: Operation and maintenance of nuclear power production, test, and research reactors. Includes operation and maintenance of auxiliary systems for supply and treatment of power, air, water, etc.

11 DESIGN AND MANUFACTURE OF NUCLEAR INSTRUMENTS, GAUGES, AND CONTROL DEVICES: Design and manufacture of hot cell and laboratory instruments and monitoring and control devices, radiographic and teletherapy equipment, activation analysis systems, etc.

NOTE: Segment data based on 94.5 percent of the estimated total nuclear-related employment universe.

Source: ERDA-601, INPO.

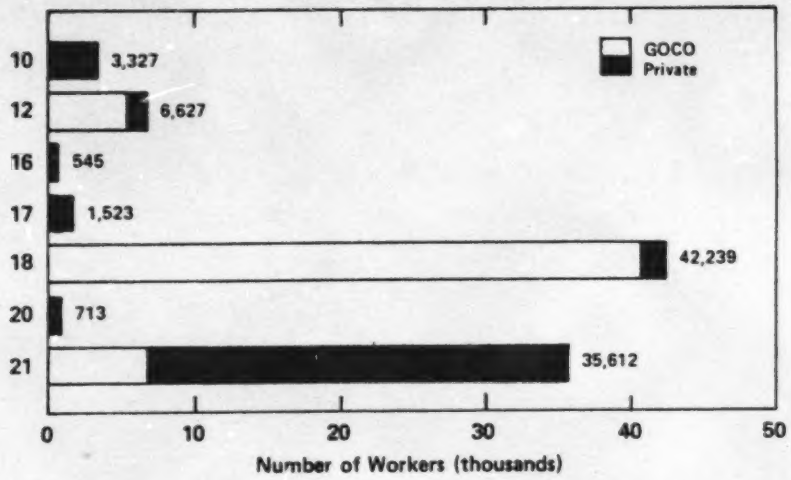

Figure 11. Nuclear-Related Employment in Industrial Segments Not Elsewhere Classified, 1981

Industrial Segment Definitions

10 RADIOISOTOPES: Manufacture, processing, and packaging of radioisotopes, including radiochemicals, radiopharmaceuticals, and other radioactive labeled compounds. Includes irradiation of medical supplies, food, and agricultural products, and of commercial materials. Excludes in-plant processing incidental to another activity.

12 ACCELERATORS: The design, engineering, manufacturing and/or construction, operation/maintenance, and research and development conducted for all classes of accelerators.

16 COMMERCIAL LABORATORY SERVICES: Provides laboratory service activities for other establishments. Examples of services are activation analysis, film badge service, mass spectrometry, radiography, and physical testing.

17 HEALTH PHYSICS AND INDUSTRIAL SAFETY: Establishes, evaluates, and monitors working conditions for compliance with industrial safety and radiation exposure standards.

18 WEAPONS DEVELOPMENT AND PRODUCTION: Develops, designs, tests, and fabricates nuclear weapons.

20 INDUSTRIAL RADIOGRAPHY: Commercial radiographic services. Excludes in-plant radiography where its use is incidental to another activity.

21 MISCELLANEOUS: Activities not classified in any of the above segments, such as consultant services, laundry services, and leasing services.

NOTE: Segment data based on 94.5 percent of the estimated total nuclear-related employment universe.

Source: ERDA-601, INPO.

94.5 percent (235,744 workers) were allocated to the 21 industrial segments. Figures 8 through 11 gather this industrial segment employment data into four groups of related industrial segment activities. The industrial segments of the remaining 13,789 nuclear-related workers are unknown. See Table B-9 in Appendix B for detailed information on GOCO private employment by industrial segment.

Figure 8 contains a bar chart and definitions of the four segments that are related to the fuel cycle. Segments 2 (processing and enrichment of reactor fuel materials) and 7 (chemical reprocessing and disposal of irradiated materials) are the largest segments and consist primarily of GOCO workers. Segments 1, 2, 5, and 6 are all concerned with the "front-end" of the fuel cycle and are affected by the demand for nuclear fuel. Segment 2 (processing and enrichment of reactor fuel materials) has been affected by the completion of the Cascade Program at all three GOCO enrichment plants. This program, which increased enrichment plant efficiency, had resulted in unusually high employment during the 1970s as the improvement work was underway. The "back-end" segment (chemical reprocessing and disposal of irradiated materials) has seen steady growth as the federal government has taken steps to deal with nuclear-related wastes.

Figure 9 contains a bar chart and definitions of the four industrial segments that are research-related (note: workers in other segments may be involved in research also, although the primary industrial segment activity for their establishment is not research-related). More than half of all workers in these four segments are GOCO workers, with the largest segment of the four (19, research and development in nuclear energy) employing over 13,000 GOCO workers.

Figure 10 contains nuclear-related employment in the five industrial segments related to the design, manufacture, and operation of nuclear reactors, reactor components, and reactor facilities. GOCO employment makes up a very small percent of total employment in these segments, with most GOCO workers in segment 8 (design and engineering of nuclear facilities). Segment 9, reactor operation and maintenance, consists mainly of utility company workers (34,650 of the total of 41,649 workers in segment 9). Other workers in this segment are involved with research or test reactors. Both segments related to new reactor facilities (segment 4, reactor and reactor component design and manufacture, and segment 8, design and engineering of nuclear facilities) have experienced large declines in total employment from previous years as the number of new reactor orders fell and slowdowns of facilities under construction occurred.

Nuclear-related employment and industrial segment definitions for the remaining seven segments not appearing in Figures 8 through 10 are contained in Figure 11. Segment 18, weapons development and production, is the largest of all 21 segments and consists of 96.4 percent GOCO workers. With the exception of the miscellaneous segment (21), the other industrial segments in Figure 11 are relatively small.

Figure 12 groups the industrial segment employment into fuel cycle related activities (9.9 percent); research related activities (8.3%); activities related to the design, manufacture, and operation of nuclear reactors, reactor components, and reactor facilities (43.4 percent); and all other segments not elsewhere classified (38.4 percent).

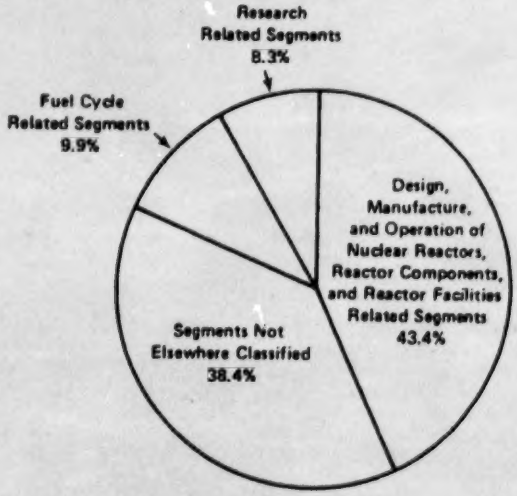
Research Related Segments 8.3%
Fuel Cycle Related Segments 9.9%
Design, Manufacture, and Operation of Nuclear Reactors, Reactor Components, and Reactor Facilities Related Segments 43.4%
Segments Not Elsewhere Classified 38.4%

Figure 12. Nuclear-Related Employment in Related Industrial Segment Groups, 1981

NOTE: Segment data based on 94.5 percent of the estimated total nuclear-related employment universe.

Source: ERDA-601, INPO.

Other Nuclear Employment Data

Table 2-1 contains total 1981 nuclear employment data from the ERDA-601 survey (including utility data collected by INPO) and other sources. There were an estimated 268,605 workers employed in nuclear-related activities in 1981 with nearly 93 percent (249,533) in the ERDA-601 field. The uranium mining industry employed the largest segment of workers not included in the survey (almost 5 percent); the U.S. Department of Energy (DOE) and the Nuclear Regulatory Commission (NRC) each employed 1 percent; and state and local governments employed only a fraction of a percent. Detailed tables of these supplemental data appear in Appendix B.

TABLE 2-1. TOTAL NUCLEAR-RELATED EMPLOYMENT, 1981

Activity		Employment
BLS-defined field[a]		249,533
Mining[b]		11,768
State and local government[c]		782
Federal government		
DOE	3,365	
NRC	3,157	
Total	6,522	6,522
Total		268,605

[a]Estimate.

[b]1980 data.

[c]FY 1979 data.

Sources: ERDA-601, Ruth C. Johnson, "Occupational Employment in Nuclear Power Utilities," working paper (Oak Ridge, Tennessee: Oak Ridge Associated Universities, 1981); U.S. Department of Energy, *Statistical Data of the Uranium Industry* (Grand Junction Office, Colorado, various years); Department of Health and Human Services, Food and Drug Administration, *Report of State and Local Radiological Health Programs, Fiscal Year 1979* (Washington, D.C.: Department of Health and Human Services, 1980), p. 14; and DOE/NRC unpublished information.

SUMMARY

This chapter examines employment in nuclear-related activities in 1981. Total estimated employment from the ERDA-601 and INPO survey is 249,533, of which 63.1 percent were private sector workers and the remainder were GOCO. Engineers made up 15.3 percent; scientists, 5.1 percent; and technicians, 17.5 percent of total employment. Nuclear employment was concentrated in the Middle Atlantic and Pacific regions, which together made up one-third of total employment. Most of nuclear-related employment was in large establishments (1,000 or more employees). Economic segments containing a large proportion of the total workers included weapons (42,239 workers), reactor operation and maintenance (41,649), miscellaneous activities (35,612), and design and engineering of nuclear facilities (25,535). In addition to the 249,533 estimated workers in the BLS-defined field, supplemental data on uranium mining, state and local government, and the federal government's Department of Energy and Nuclear Regulatory Commission indicate an additional 19,072 workers in nuclear-related activities.

NOTES

1. U.S. Bureau of Census, *Statistical Abstract of the United States, 1980* (Washington, D.C.: U.S. Government Printing Office, 1980), p. 419.

2. These were computed by using state employment estimates for April 1981 from U.S. Department of Labor, *Monthly Labor Review*, vol. 104, no. 7 (July 1981), p. 65.

3. Data on total employment by establishment size are from U.S. Bureau of Census, *County Business Patterns, 1979* (Washington, D.C.: U.S. Government Printing Office, 1981). These data are for 1979 and are the most recent available.

CHAPTER 3
EMPLOYMENT TRENDS IN NUCLEAR-RELATED ACTIVITIES

INTRODUCTION

This chapter examines employment trends in the nuclear or nuclear-related field for the years 1968-1981. Although data are available for years prior to 1968, missing data, limited coverage, and changes in definitions hinder their use.[1] From 1968 to the present survey, the data are comparable.

TOTAL EMPLOYMENT TRENDS

Figure 13 shows employment trends from the ERDA-601 surveys from 1968 through 1981. Total employment in the field has grown from 141,727 in 1968 to 249,533 in 1981, a growth rate of 4.5 percent per year. This compares with a growth rate in the total U.S. economy's employment of 2.4 percent per year for the same period.[2] Since the last survey (1977), employment has grown from 226,954 to 249,533--a growth rate of 2.4 percent per year.

As shown in Figure 13, all of the growth in nuclear-related employment has occurred in the private sector. GOCO employment has remained fairly constant, varying between 85,000 and 100,000 workers during this period. Private sector employment growth from 1968-1981 was 10.6 percent per year.

SCIENTISTS, ENGINEERS, AND TECHNICIANS

The structure of employment in nuclear-related activities has changed considerably over the years examined. Table 3-1 shows the percent of total GOCO employment and the percent of total private employment in each of the major occupational groups in 1968, 1977, and 1981. In both the GOCO and private sectors, the portion of employment composed of engineers and scientists has fallen, while the "other" group has increased its share. This is most likely due to a general movement away from research and development activities to more commercial activities by the private sector. The percent of total employment made up of technicians has declined slightly over this period. There has been only a small decline in the percent of engineers in the GOCO sector. See Appendix B

(Supplemental Tables) for detailed data for individual scientist, engineer, and technician occupations.

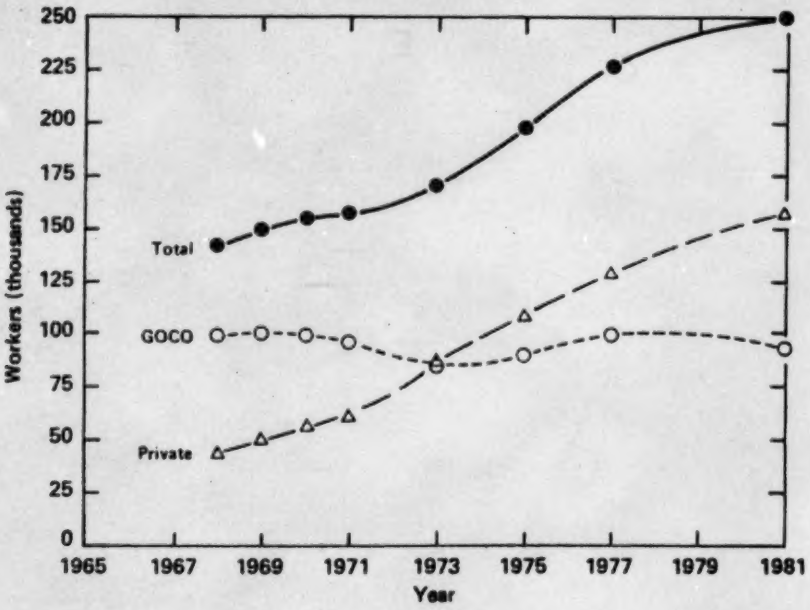

Figure 13. GOCO/Private Employment Trends, 1968-1981

NOTE: 1981 data is an estimate.

Source: 1981 ERDA-601, preceeding BLS surveys, and INPO survey data.

TABLE 3-1. PERCENTAGE DISTRIBUTION OF MAJOR OCCUPATIONS IN NUCLEAR-RELATED ACTIVITIES, 1968-1981

	Year					
	1968		1977		1981[a]	
Occupation	GOCO	Private	GOCO	Private	GOCO	Private
Scientist	10.7	5.6	10.2	3.8	8.8	3.0
Engineer	13.0	22.9	14.4	20.7	12.9	16.7
Technician	16.6	21.1	16.4	19.9	16.3	18.1
Other	59.7	50.4	59.0	55.6	62.0	62.2
Total	100.0	100.0	100.0	100.0	100.0	100.0

[a]1981 data based upon 71 percent of the estimated total nuclear-related employment universe.

Source: ERDA-601.

ESTABLISHMENT SIZE TRENDS

Figure 14 details the percent distribution of establishments classified by the number of employees in nuclear-related activities in 1968, 1977, and 1981. As shown by the block chart, there has been very little change in the size distribution of establishments during this period, with a slight growth in the percent of establishments with 50-499 employees and a slight decline in the portion of establishments with less than 50 employees. Approximately 90 percent of all establishments have less than 500 employees.

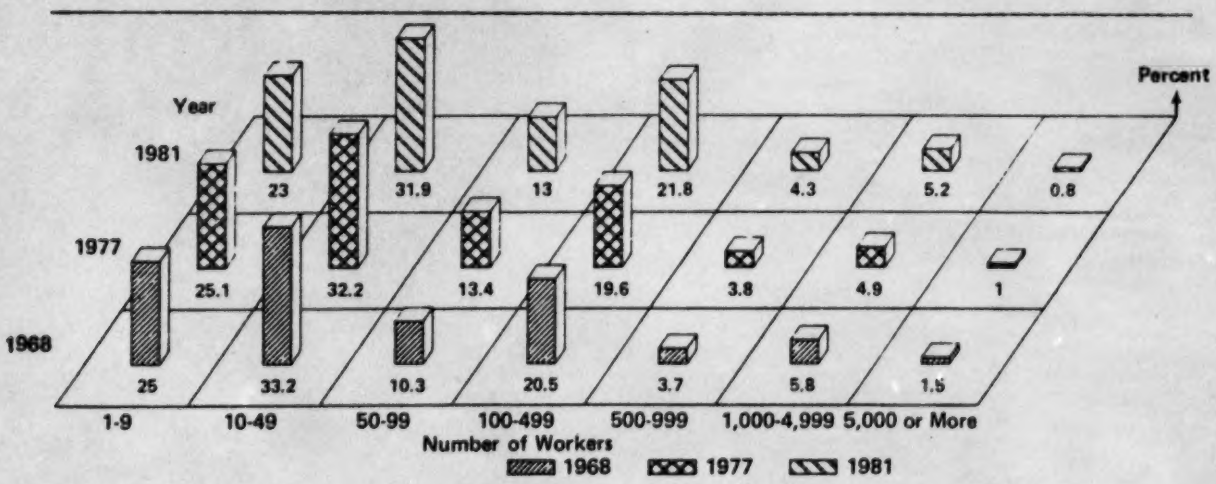

Figure 14. Percentage Distribution Trends of Establishments by Number of Workers

NOTE: 1981 data based on 84 percent of the estimated total nuclear-related employment universe.

Source: 1981 ERDA-601, preceeding BLS surveys, and INPO survey data.

The percent of total employment in each size group shows a different distribution. Table 3-2 compares the percent distribution of employment by size of establishment in 1968, 1977, and 1981. In all years, establishments with 1,000 or more employees have the major portion of total workers but only make up about 7 percent of all establishments. Some shifts have occurred from 1968 to 1977 in the employment distribution, most notably a reduction in the largest establishments share and a growth in the 100-499 worker size group's share.

TABLE 3-2. NUCLEAR-RELATED EMPLOYMENT DISTRIBUTION BY ESTABLISHMENT SIZE--1968, 1977, AND 1981

Establishment Size (Employees)	1968	1977	1981[a]
1-9	0.3	0.5	0.4
10-49	2.4	3.1	3.0
50-99	2.4	3.9	3.6
100-499	14.0	17.2	20.1
500-999	9.3	10.3	11.1
1000-4999	39.6	41.6	41.2
5000 or more	31.9	23.5	20.5
Total	100.0[b]	100.0[b]	100.0[b]

[a]Based upon 84 percent of the estimated total nuclear-related employment universe.

[b]Totals may not add to 100.0 due to rounding.

Source: 1981 ERDA-601, preceeding BLS surveys, and INPO survey.

REGIONAL EMPLOYMENT TRENDS

Table 3-3 details the percent distribution of nuclear-related employment for regions for the years 1968, 1977, and 1981. There has been little change in the regional distribution of employment during this period; the only large shift was a reduction of employment share in the Mountain region and a gain in the Middle Atlantic and South Atlantic.

TRENDS IN RESEARCH AND DEVELOPMENT EMPLOYMENT

Table 3-4 contains the percent of all nuclear-related scientists and engineers involved in research and development (R&D) for the period 1968-1981. There has been a steady decline in R&D involvement for all groups during this period, although the trend is most pronounced in the private sector. The exception is R&D among private sector engineers, which grew slightly from 1977 to 1981. These data also indicate that the GOCO sector is more involved in R&D than the private sector, although there has been a large decrease in GOCO engineering R&D from 1977 to 1981.

TABLE 3-3. REGIONAL DISTRIBUTION OF NUCLEAR-RELATED EMPLOYMENT--1968, 1977, AND 1981

Region	1968	1977	1981[a]
New England	3.6	6.1	6.2
Middle Atlantic	13.6	16.8	17.8
North Central	12.3	14.0	11.4
West North Central	6.1	3.5	4.5
South Atlantic	7.9	12.3	12.6
East South Central	12.1	11.9	11.3
West South Central	1.5	2.0	5.0
Mountain	21.6	13.3	12.3
Pacific	21.3	20.1	18.8

[a]Based upon 84 percent of the estimated total nuclear-related employment universe.

Source: 1981 ERDA-601, preceeding BLS surveys, and INPO survey.

TABLE 3-4. PERCENT OF NUCLEAR-RELATED SCIENTISTS AND ENGINEERS INVOLVED IN RESEARCH AND DEVELOPMENT ACTIVITIES, 1968-1981

	GOCO		Private		Total	
Year	Scientists	Engineers	Scientists	Engineers	Scientists	Engineers
1968	85.3	70.0	69.9	44.3	82.5	58.9
1969	84.2	71.1	66.4	34.9	80.7	54.1
1970	84.5	68.9	58.2	30.7	79.3	49.9
1971	84.6	68.5	54.7	23.8	78.3	44.6
1973	83.4	67.4	38.5	14.8	70.3	33.8
1975	79.6	67.2	44.6	12.0	66.8	28.8
1977	79.5	70.5	40.9	10.7	66.9	31.5
1981[a]	76.4	58.4	33.4	12.8	60.4	27.0

[a]Based upon 71 percent of the estimated total nuclear-related employment universe.

NOTE: These were workers who spent the greatest proportion of their time performing, managing, or administering basic and applied research. See definition in Appendix C.

Source: 1981 ERDA-601, preceeding BLS surveys, and INPO survey.

TRENDS IN SEGMENT EMPLOYMENT

Table 3-5 details employment by industrial segment in nuclear-related activities in 1975, 1977, 1981. Prior to 1975, the survey used different segment classifications and/or definitions. The definitions for the economic segments in Table 3-5 are in Appendix C.

These data indicate considerable change in the nature of nuclear-related work for this period. Segments that have grown substantially include 9 (reactor operation and maintenance), 17 (health physics), 18 (weapons), and the miscellaneous category (segment 21). Segments experiencing decline include 1 (uranium milling), 2 (reactor fuel processing), 4 (design and manufacturing of reactors and reactor components), 8 (design and engineering of nuclear facilities), 15 (reactor research and evaluation), 16 (commercial lab services), and 19 (R&D in nuclear energy). Segments 4 (design and manufacturing of reactors and reactor components) and 8 (design and engineering of nuclear facilities), which are concerned mainly with new reactor facilities, have experienced a drop of 21,009 workers from 1977 to 1981. Both of these segments grew from 1975 to 1977.

SUMMARY

This chapter has examined employment trends in nuclear-related activities through 1981. Total nuclear-related employment has grown at a 4.5-percent annual rate from 1968 through 1981, although from 1977 to 1981 the rate was 2.4 percent per year. Virtually all of this growth was in the private sector, which grew at an annual rate of 10.6 percent. The percent of total employment composed of scientists and engineers has fallen from 1968 to 1981, although the technician share has remained fairly constant. Percent of total employment in the largest establishments (1,000 or more workers) has fallen from 1968 to 1981, although the regional distribution of nuclear-related employment has remained fairly stable.

The portion of scientists and engineers involved in research and development has declined steadily from 1968 through 1981, with the exception of private sector engineers from 1977 to 1981. Also, the distribution of engineers employment among industrial segments has changed considerably, with large increases in reactor operation and maintenance and in weapons development and

TABLE 3-5. NUCLEAR RELATED EMPLOYMENT BY INDUSTRIAL SEGMENT--1975, 1977, AND 1981

	Total Workers					
	1975		1977		1981	
Segment	Number	Percent	Number	Percent	Number	Percent
Fuel Cycle Total	26,100	13.2	28,767	12.7	23,393	9.9
1	1,700	0.9	1,926	0.8	616	0.3
2	11,400	5.8	13,729	6.0	7,027	3.0
5	3,700	1.9	2,739	1.2	2,984	1.3
6	700	0.4	845	0.4	1,058	0.4
7	8,600	4.4	9,528	4.2	11,708	5.0
Research Total	31,900	16.2	28,908	12.8	19,543	8.3
13	600	0.3	1,485	0.7	857	0.4
14	2,000	1.0	1,355	0.6	1,276	0.5
15	7,300	3.7	5,378	2.4	2,888	1.2
19	22,000	11.1	20,690	9.1	14,522	6.2
Design, Manufacture, and Operation of Nuclear Reactors, Reactor Components, and Reactor Facilities Total	84,700	42.9	100,102	44.1	102,222	43.4
3	2,400	1.2	3,799	1.7	2,863	1.2
4	27,100	13.7	34,084	15.0	24,433	10.4
8	34,200	17.3	36,893	16.3	25,535	10.8
9	12,700	6.4	17,270	7.6	41,649	17.7
11	8,300	4.2	8,056	3.5	7,742	3.3
Segments Not Elsewhere Classified Total	54,400	27.5	69,177	30.5	90,586	38.4
10	2,500	1.3	2,250	1.0	3,327	1.4
12	6,700	3.4	5,771	2.5	6,627	2.8
16	1,400	0.7	1,325	0.6	545	0.2
17	200	0.1	461	0.2	1,523	0.6
18	31,700	16.1	30,263	13.3	42,239	17.9
20	1,900	1.0	979	0.4	713	0.3
21	10,400	5.3	28,128	12.4	35,612	15.1
Total	197,500	100.0	226,954	100.0	235,744[a]	100.0

TABLE 3-5. (Continued)

Segment Definitions

1	URANIUM MILLING
2	PROCESSING AND ENRICHMENT OF REACTOR FUEL MATERIALS
3	PRODUCTION OF SPECIAL MATERIALS FOR USE IN REACTORS
4	REACTOR AND REACTOR COMPONENT DESIGN AND MANUFACTURING
5	FUEL FABRICATION
6	TRANSPORTATION OF NUCLEAR MATERIALS
7	CHEMICAL REPROCESSING AND DISPOSAL OF IRRADIATED MATERIALS
8	DESIGN AND ENGINEERING OF NUCLEAR FACILITIES
9	NUCLEAR REACTOR OPERATION AND MAINTENANCE
10	RADIOISOTOPES
11	DESIGN AND MANUFACTURE OF NUCLEAR INSTRUMENTS, GAUGES, AND CONTROL DEVICES
12	ACCELERATORS
13	ENVIRONMENTAL AND ECOLOGICAL RESEARCH AND EVALUATION
14	BIOLOGY AND MEDICAL RESEARCH
15	REACTOR RESEARCH, DEVELOPMENT, AND EVALUATION
16	COMMERCIAL LABORATORY SERVICES
17	HEALTH PHYSICS AND INDUSTRIAL SAFETY
18	WEAPONS DEVELOPMENT AND PRODUCTION
19	RESEARCH AND DEVELOPMENT IN NUCLEAR ENERGY
20	INDUSTRIAL RADIOGRAPHY
21	MISCELLANEOUS

[a]Excludes 13,789 workers (5.5 percent) whose industrial segment is unknown.

Source: 1981 ERDA-601, previous BLS surveys, and INPO survey.

production. Segments related to new reactor facilities, especially reactor manufacturing and nuclear facilities design, experienced sharp employment declines.

NOTES

1. For data on pre-1968 employment, see Joe G. Baker, *An Examination of Employment in the Atomic Energy Field*, ORAU-139 (Oak Ridge, Tennessee: Oak Ridge Associated Universities, 1978).

2. These were computed from U.S. Department of Labor, *Monthly Labor Review*, vol. 104, no. 7 (July 1981), p. 65.

APPENDIXES

APPENDIX A
SURVEY OF NONRESPONDENTS

After the initial mailing to the 1,912 establishments in the survey universe, a second mailing was sent to nonrespondents (approximately 1,200 establishments). The nonrespondents to this second mailing (approximately 900) were queried a third time. In addition to these three mailings, a file was made of all establishments which had reported nuclear-related employment of 100 or more in 1977 (the last survey year) and were nonrespondents through the three 1981 mailings. Individuals in these establishments were contacted by telephone and asked to complete the form which was subsequently mailed directly to them.

Despite these efforts, 591 establishments of the original 1,912 (30.9%) did not respond. In order to determine the extent of nuclear-related employment among these 591 nonrespondents, a telephone survey of a random sample of 100 of the nonrespondents was conducted. Each nonrespondent was asked if they had nuclear-related employment as of April 1981; the approximate number of nuclear-related employees (using the definitions of the mail-out survey); the type of nuclear-related activity (i.e., industrial segment); establishment type (GOCO, private, nonprofit); and whether they were engaged in nuclear-related activities in 1977 (see the telephone form, Attachment A-1). Obviously, a telephone interview is different from a mailed questionnaire; the telephone interviewee cannot read definitions and does not have time to research the questions. A major difference in the mailed and telephone surveys was the allocation of activities among industrial segments. In the mailed questionnaire, the respondent chose the industrial segment that best described their major activity from a list of definitions. In the telephone surveys, the interviewee described their activity to the interviewer who placed them in an industrial segment. This segment description was then read back to the interviewee. The effect of possible biases on the nonresponse survey is unknown.

Table A-1 compares the telephone survey with respondents to the mail-out survey. Fifty-six percent of the establishments in the telephone survey reported that they were in-scope. This difference is not statistically significant from the proportion in-scope among the mail-out survey respondents.

TABLE A-1. FREQUENCY DISTRIBUTIONS OF MAIL-OUT AND TELEPHONE SURVEYS

	Survey			
	Mail-Out		Telephone	
	Number	Percent	Number	Percent
Total response	1,321	100.0	100	100.0
In-scope[a]	643	48.7	56	56.0
Out-of-scope	604	45.7	36	36.0
Other[b]	74	5.6	8	8.0

[a]The t-statistic for difference in in-scope response is 1.40.

[b]Includes out of business, refusal, returned to sender, and unable to locate.

Table A-2 compares the segment distribution of establishments for both surveys. A much higher percentage of the in-scope nonrespondent establishments are in the miscellaneous segment (Segment 21) than are respondent in-scope establishments.

Table A-3 contains summary statistics for the mail-out and telephone surveys. Both surveys have considerable variance in employment per establishment, and although the absolute difference between sample means is large, it is not statistically significant.

Table A-4 contains confidence intervals for the telephone sample statistics. Because of the large variance in sample statistics, the estimated population statistics have large confidence intervals about them. This results in considerable uncertainty in the estimate. However, even the extreme low end of the confidence intervals indicates a substantial number of establishments and employees in the nonresponse population engaged in nuclear-related activities. Unfortunately, earlier surveys of nuclear-related employment did not sample the nonresponse population and therefore no comparison is possible.

TABLE A-2. MAIL-OUT AND TELEPHONE SURVEY EMPLOYMENT AND ESTABLISHMENTS

Segment Number	Survey							
	Mail-Out				Telephone			
	Establishments		Employment		Establishments		Employment	
	No.	Percent	No.	Percent	No.	Percent	No.	Percent
1	5	0.8	616	0.4	0	0.0	0	0.0
2	10	1.6	6657	4.8	0	0.0	0	0.0
3	15	2.4	2793	2.0	2	3.6	70	0.9
4	57	9.0	10421	7.5	9	16.1	900	12.1
5	6	0.9	2984	2.1	0	0.0	0	0.0
6	13	2.0	1038	0.7	1	1.8	20	0.3
7	22	3.5	11601	8.3	2	3.6	107	1.4
8	66	10.4	18752	13.4	2	3.6	190	2.5
9	24	3.8	6871	4.9	3	5.6	128	1.7
10	26	4.1	827	0.6	1	1.8	2500	33.5
11	88	13.8	7395	5.3	4	7.1	347	4.6
12	11	1.7	6015	4.3	0	0.0	0	0.0
13	9	1.4	857	0.6	0	0.0	0	0.0
14	15	2.4	1276	0.9	0	0.0	0	0.0
15	9	1.4	2485	1.8	2	3.6	65	0.9
16	32	5.0	545	0.4	0	0.0	0	0.0
17	20	3.1	1523	1.1	0	0.0	0	0.0
18	13	2.0	32322	23.2	1	1.8	—[a]	0.0
19	17	2.7	9809	7.0	0	0.0	0	0.0
20	30	4.7	705	0.5	1	1.8	8	0.1
21	149	23.4	13984	10.0	28	50.0	3130	41.9
Total	637[b]	100.0	139476	100.0	56	100.0	7465	100.0

[a]This establishment would not disclose nuclear-related employment, although they were in-scope.

[b]This figure excludes six in-scope responses that did not have sufficient segment data.

TABLE A-3. SUMMARY STATISTICS, IN-SCOPE ESTABLISHMENTS MAIL-OUT AND TELEPHONE SURVEYS

	Survey	
	Mail-Out	Telephone
Mean employment	219.0	143.6
Standard deviation	744.7	381.5
Observations	637	52[a]
t-test, difference in means	1.24	

[a]Only 52 of 56 firms reported employment.

TABLE A-4. CONFIDENCE INTERVALS AROUND ESTIMATED NONRESPONSE STATISTICS

Variable	Estimated Population Statistic[a]	90 Percent Confidence Interval	95 Percent Confidence Interval
Mean in-scope establishment employment	143.6	86 to 201	76 to 212
In-scope establishments			
Number	331	287 to 375	278 to 384
Portion	.56	.485 to .635	.471 to .649
Total nuclear employment	47,515	22,259 to 72,771	17,514 to 77,516

[a]Estimated value of the variable for the nonresponse population of 591 establishments.

Estimates of total segment employment for the nonresponse universe with 90 percent and 95 percent confidence intervals are, for most of the estimates, extremely large. Because of this uncertainty, only the estimated employment in segments 4 and 21 was used in this report. These segments had 9 and 28 establishments, respectively, in the telephone survey; therefore, their employment estimates were more reliable than those for other segments.

In summary, the nonrespondents to the mail-out survey are similar to the respondents in terms of the portion of establishments in nuclear-related activities and the number of employees per establishment. However, the distribution of establishments by industrial segment differs between the respondents and nonrespondents. The inclusion of the data obtained from the telephone survey of nonrespondents allowed a more accurate measure of 1981 nuclear-related employment.

ATTACHMENT A-1

Nonresponse Survey

Caller: _____ Date: _____

Firm Name/Address: _____

_____

_____

_____

Contact Person: _____ Phone _____

FTS _____

---

(1) Did your establishment have employees engaged in nuclear-related activities in April 1981? ☐ Yes ☐ No

(2) What was the approximate number? _____ ☐ Don't know

(3) What type of nuclear-related activity were the largest portion of workers engaged in? Segment ☐ ☐

(4) Was your establishment engaged in nuclear-related activities in 1977?
☐ Yes ☐ No ☐ Don't know

(5) What is your establishment type? Non-profit research establishment ☐
Private industrial and/or research establishment ☐
DOE-owned research laboratory, test facility, and/or production facility ☐

Remarks: _____

_____

_____

_____

_____

_____

APPENDIX B
ESTIMATION METHOD AND SUPPLEMENTAL TABLES

Of the 2,053 forms that were mailed, 1,462 were returned. Out of these returned forms, usable data were collected for a total nuclear-related employment figure of 177,452. Forms that contained usable total employment information but were incorrectly filled out in terms of occupations, R&D employment, or other factors totaled 10,418, bringing the total to 187,870. Equal Employment Opportunity Commission forms obtained from the Department of Energy provided total employment for 5 GOCOs representing 14,148 nuclear-related workers, giving a total of 202,018.

As discussed in Appendix A, the estimated nuclear-related employment in the 591 nonresponse establishments was 47,515, which when added gives the total estimated universe of 249,533. All but 13,789 of this total could be allocated by industrial segment.

Occupational data were available only for 177,452 workers (71.1 percent of the total). Estimates of occupational distribution (and R&D involvement) for the remaining 72,081 workers were computed by assuming that the estimated employment was broken into the same occupational shares as the total known employment in a given industrial segment and establishment type (GOCO or private) for which occupational data were available. Because the INPO survey had covered all of the utilities, these data were excluded for estimating the unknown occupational distribution. The occupational distribution of the 13,789 workers whose industrial segment was unknown was assumed to be the same as the private sector occupational distribution in total.

The footnotes in the following supplemental tables give the percentage of the estimated total covered in the survey.

TABLE B-1. EMPLOYMENT IN THE NUCLEAR ENERGY FIELD, 1968-1981

	1968	1969	1970	1971	1973	1975	1977	1981[a]
Private	42,728	49,794	55,515	61,464	85,756	108,092	128,359	157,520
Scientists	2,393	2,524	2,507	2,657	3,819	5,281	4,888	4,790
Engineers	9,802	11,690	12,966	14,781	21,098	30,177	26,630	26,260
Technicians	9,007	10,939	13,049	14,332	17,928	22,915	25,509	28,580
Other	21,526	24,641	26,993	29,694	42,911	49,719	71,332	97,890
GOCO	98,999	99,636	98,609	95,470	85,109	89,374	98,595	92,010
Scientists	10,631	10,468	10,154	9,782	9,746	9,871	10,082	8,070
Engineers	12,833	13,205	13,065	12,818	11,943	13,056	14,216	11,910
Technicians	16,386	16,148	16,415	15,383	13,905	14,142	16,138	15,010
Other	59,149	59,815	58,975	57,487	49,515	52,305	58,159	57,020
Total	141,727	149,430	154,124	156,934	170,865	197,466	226,954	249,530

[a]1981 data based on 71 percent of estimated total nuclear-related employment universe.

Source: 1981 ERDA-601, preceeding BLS surveys, and INPO survey.

TABLE B-2. SCIENTISTS AND ENGINEERS INVOLVED IN RESEARCH AND DEVELOPMENT ACTIVITIES IN THE NUCLEAR ENERGY FIELD, 1968-1981

	Total			GOCO			Private		
	Scientists and Engineers	Scientists	Engineers	Scientists and Engineers	Scientists	Engineers	Scientists and Engineers	Scientists	Engineers
1968									
Number	24,078	10,746	13,332	18,068	9,074	8,994	6,010	1,672	4,338
Percent[a]	67.5	82.5	58.9	77.0	85.3	70.0	49.3	69.9	44.3
1969									
Number	23,957	10,487	13,470	18,205	8,811	9,394	5,752	1,676	4,076
Percent	62.4	80.7	54.1	75.3	84.2	71.1	40.5	66.4	34.9
1970									
Number	23,032	10,043	12,989	17,593	8,585	9,008	5,439	1,458	3,981
Percent	59.5	79.3	49.9	75.8	84.5	68.9	35.3	58.2	30.7
1971									
Number	22,033	9,735	12,298	17,054	8,278	8,776	4,979	1,457	3,522
Percent	55.0	78.3	44.6	75.5	84.6	68.5	28.6	54.7	23.8
1973									
Number	20,771	9,604	11,167	16,177	8,132	8,045	4,594	1,472	3,122
Percent	44.6	70.3	33.8	74.6	83.4	67.4	18.4	38.5	14.8
1975									
Number	22,589	10,117	12,472	16,624	7,855	8,769	5,965	2,359	3,606
Percent	38.7	66.8	28.8	72.5	79.6	67.2	16.8	44.6	12.0
1977									
Number	22,891	10,017	12,874	18,042	8,020	10,022	4,849	1,997	2,852
Percent	41.0	66.9	31.5	74.3	79.5	70.5	15.4	40.9	10.7
1981[b]									
Number	18,090	7,770	10,320	13,120	6,170	6,950	4,970	1,600	3,370
Percent	35.4	60.4	27.0	65.7	76.4	58.4	16.0	33.4	12.8

[a]The percent rows on this table show the percentage of all in that occupation group involved in research and development.

[b]1981 data based on 71 percent of estimated total nuclear-related employment universe.

Source: 1981 ERDA-601, preceeding BLS surveys, and INPO survey.

TABLE B-3. OCCUPATIONAL TRENDS FOR NUCLEAR-RELATED SCIENTISTS

Occupation	1968	1969	1970	1971	1973	1975	1977	1981[a]
Mathematicians								
GOCO	1,495	1,559	1,504	1,414	1,415	1,588	1,456	1,280
Private	297	250	289	279	416	497	450	550
Total physical scientists								
GOCO	7,765	7,541	7,271	6,984	6,846	6,847	6,904	5,720
Private	1,807	1,976	1,882	1,825	2,112	2,888	2,858	2,640
Chemists								
GOCO	3,012	2,971	2,828	2,829	2,743	2,532	2,506	1,790
Private	779	816	817	838	990	1,294	1,073	1,270
Geologists and geophysicists								
GOCO	56	59	58	58	99	152	302	340
Private	43	68	63	53	94	266	209	140
Physicists								
GOCO	3,680	3,580	3,531	3,278	3,284	3,386	3,212	2,490
Private	772	835	765	725	661	887	986	790
Metallurgists								
GOCO	581	516	501	423	478	370	364	370
Private	175	206	203	167	236	214	300	170
All other physical scientists								
GOCO	436	415	353	396	242	407	520	730
Private	38	51	34	42	131	227	290	270
Total life scientists								
GOCO	1,371	1,368	1,379	1,384	1,485	1,436	1,722	1,070
Private	289	298	336	553	1,291	1,896	1,580	1,600
Biological								
GOCO	819	724	686	697	808	710	771	560
Private	93	82	104	260	918	1,138	795	660
Medical								
GOCO	81	69	107	91	62	103	142	60
Private	14	10	13	31	38	305	141	110
Health physics								
GOCO	442	498	464	480	455	372	580	420
Private	178	194	210	246	320	333	420	680
All other life scientists								
GOCO	29	77	122	116	160	251	229	30
Private	4	12	9	16	15	120	224	150

[a]1981 data based on 71 percent of estimated total nuclear-related employment universe.

Source: 1981 ERDA-601, preceeding BLS surveys, and INPO survey.

TABLE B-4. OCCUPATIONAL TRENDS FOR NUCLEAR-RELATED ENGINEERS

Occupation	1968	1969	1970	1971	1973	1975	1977	1981[a]
Total engineers								
GOCO	12,833	13,205	13,065	12,818	11,943	13,056	14,216	11,910
Private	9,802	11,690	12,966	14,781	21,098	30,177	26,630	26,260
Chemical								
GOCO	1,488	1,584	1,517	1,559	1,444	1,448	1,573	1,540
Private	538	558	615	588	894	1,000	828	950
Civil								
GOCO	388	350	385	412	401	390	475	450
Private	630	709	975	1,181	1,888	3,336	3,354	2,700
Electrical and electronic								
GOCO	3,251	3,237	3,310	3,167	3,019	3,080	3,377	2,800
Private	1,871	2,056	2,458	2,565	3,760	4,922	4,422	4,570
Mechanical								
GOCO	3,992	3,774	3,971	3,815	3,874	3,860	4,085	2,850
Private	3,482	4,345	4,693	5,340	6,949	9,151	7,459	8,210
Nuclear and reactor								
GOCO	1,132	1,341	1,360	1,345	945	1,350	1,510	1,300
Private	1,590	1,937	1,907	2,316	3,537	5,032	4,137	3,130
Metallurgical								
GOCO	478	493	477	491	471	525	464	330
Private	426	462	538	525	654	949	689	480
All other engineers								
GOCO	2,154	2,426	2,045	2,029	1,789	2,403	2,732	2,640
Private	1,265	1,623	1,780	2,266	3,416	5,787	5,741	6,220

[a]1981 data based on 71 percent of estimated total nuclear-related employment universe.

Source: 1981 ERDA-601, preceeding BLS surveys, and INPO survey.

TABLE B-5. OCCUPATIONAL TRENDS FOR NUCLEAR-RELATED TECHNICIANS

Occupation	1968	1969	1970	1971	1973	1975	1977	1981[a]
All technicians								
GOCO	16,386	16,148	16,415	15,383	13,905	14,142	16,138	15,010
Private	9,007	10,939	13,049	14,332	17,928	22,915	25,509	28,580
Draftsmen								
GOCO	2,044	2,136	2,201	2,173	1,996	1,893	1,850	1,500
Private	2,628	3,257	3,920	4,985	5,948	8,409	7,786	6,010
Electrical and electronic								
GOCO	3,856	4,090	3,918	3,429	3,110	3,083	3,617	3,450
Private	1,400	1,468	1,511	1,745	2,127	2,458	3,025	4,260
All other engineering technicians								
GOCO	3,477	3,373	3,767	3,557	3,163	3,103	3,224	2,890
Private	1,491	2,033	2,227	2,314	3,874	4,086	5,074	4,100
Physical science								
GOCO	1,902	1,987	2,326	2,178	2,456	2,460	2,014	1,630
Private	584	667	815	867	704	777	694	1,160
Life science								
GOCO	434	409	427	363	511	564	369	340
Private	101	127	141	83	237	566	384	240
Health physics technicians								
GOCO	944	1,000	998	1,073	1,039	927	947	790
Private	334	502	555	619	857	975	1,444	2,800
Nuclear reactor operators								
GOCO	500	460	393	342	348	475	1,035	580
Private	386	615	769	994	1,260	1,572	3,057	5,120
All other technicians								
GOCO	3,229	2,693	2,385	2,268	1,282	1,637	3,082	3,830
Private	2,083	2,270	3,111	2,725	2,921	4,072	4,045	4,890

[a]1981 data based on 71 percent of estimated total nuclear-related employment universe.

Source: 1981 ERDA-601, preceeding BLS surveys, and INPO survey.

TABLE B-6. PERCENTAGE DISTRIBUTION TRENDS OF NUCLEAR-RELATED SCIENTISTS

Occupation	1968	1971	1973	1975	1977	1981[a]
Total scientists						
GOCO	10,631	9,782	9,746	9,871	10,082	8,070
Private	2,393	2,657	3,819	5,281	4,888	4,790
Mathematicians						
GOCO	14.1%	14.5%	14.5%	16.1%	14.4%	15.9%
Private	12.4	10.5	10.9	9.4	9.2	11.5
Chemists						
GOCO	28.3	28.9	28.1	25.7	24.9	22.2
Private	32.5	31.5	25.9	24.5	22.0	26.4
Geologists and geophysicists						
GOCO	0.5	0.6	1.0	1.5	3.0	4.2
Private	1.8	2.0	2.5	5.0	4.3	2.9
Physicists						
GOCO	34.6	33.5	33.7	34.3	31.9	30.9
Private	32.3	27.3	17.3	16.8	20.2	16.6
Metallurgists						
GOCO	5.5	4.3	4.9	3.7	3.6	4.5
Private	7.3	6.3	6.2	4.0	6.1	3.5
Other physical scientists						
GOCO	4.1	4.0	2.5	4.1	5.2	9.0
Private	1.6	1.6	3.4	4.3	5.9	5.7
Biological scientists						
GOCO	7.7	7.1	8.3	7.2	7.6	6.9
Private	3.9	9.8	24.0	21.5	16.3	13.8
Medical scientists						
GOCO	0.8	0.9	0.6	1.0	1.4	1.0
Private	0.6	1.3	1.0	5.8	2.9	2.2
Health physicists						
GOCO	4.2	4.9	4.7	3.8	5.8	5.3
Private	7.4	9.2	8.4	6.3	8.6	14.2
All other life scientists						
GOCO	0.3	1.2	1.6	2.5	2.3	0.3
Private	0.2	0.6	0.4	2.3	4.6	3.2

[a]1981 data based on 71 percent of estimated total nuclear-related employment universe.

Source: 1981 ERDA-601, preceeding BLS surveys, and INPO survey.

TABLE B-7. PERCENTAGE DISTRIBUTION TRENDS OF NUCLEAR-RELATED ENGINEERS

Occupation	1968	1971	1973	1975	1977	1981[a]
Total						
GOCO	12,833	12,818	11,943	13,056	14,216	11,910
Private	9,802	14,781	21,098	30,177	26,630	26,260
Chemical						
GOCO	11.6%	12.2%	12.1%	11.1%	11.1%	12.9%
Private	5.5	4.0	4.2	3.3	3.1	3.6
Civil						
GOCO	3.0	3.2	3.4	3.0	3.3	3.7
Private	6.4	8.0	8.9	11.1	12.6	10.3
Electrical and electronics						
GOCO	25.3	24.7	25.3	23.6	23.8	23.5
Private	19.1	17.4	17.8	16.3	16.6	17.4
Mechanical						
GOCO	31.1	29.8	32.4	29.6	28.7	23.9
Private	35.5	36.1	32.9	30.3	28.0	31.3
Nuclear and reactor						
GOCO	8.8	10.5	7.9	10.3	10.6	11.0
Private	16.2	15.7	16.8	16.7	15.5	11.9
Metallurgical						
GOCO	3.7	3.8	3.9	4.0	3.3	2.8
Private	4.3	3.5	3.1	3.1	2.6	1.8
All other						
GOCO	16.8	15.8	15.0	18.4	19.2	22.2
Private	12.9	15.3	16.2	19.2	21.6	23.7

[a]1981 data based on 71 percent of estimated total nuclear-related employment universe.

Source: 1981 ERDA-601, preceeding BLS surveys, and INPO survey.

TABLE B-8. PERCENTAGE DISTRIBUTION TRENDS OF NUCLEAR-RELATED TECHNICIANS

Occupation	1968	1971	1973	1975	1977	1981[a]
All technicians						
GOCO	16,386	15,383	13,905	14,142	16,138	15,010
Private	9,007	14,332	17,928	22,915	25,509	28,580
Draftsmen						
GOCO	12.5%	14.1%	14.3%	13.4%	11.5%	10.0%
Private	29.2	34.8	33.2	36.7	30.5	21.0
Electrical and electronic						
GOCO	23.5	22.3	22.4	21.8	22.4	23.0
Private	15.5	12.2	11.9	10.7	11.9	14.9
All other engineering technicians						
GOCO	21.2	23.1	22.7	21.9	20.0	19.2
Private	16.5	16.1	21.6	17.8	19.9	14.3
Physical science						
GOCO	11.6	14.1	17.7	17.4	12.5	10.9
Private	6.5	6.0	3.9	3.4	2.7	4.1
Life science						
GOCO	2.6	2.4	3.7	4.0	2.3	2.2
Private	1.1	0.6	1.3	2.5	1.5	0.8
Health physics technicians						
GOCO	5.8	7.0	7.5	6.6	5.9	5.3
Private	3.7	4.3	4.8	4.3	5.7	9.8
Nuclear reactor operator						
GOCO	3.1	2.2	2.5	3.4	6.4	3.9
Private	4.3	6.9	7.0	6.9	12.0	17.9
All other						
GOCO	19.7	14.7	9.2	11.6	19.1	25.5
Private	23.1	19.0	16.3	17.8	15.9	17.1

[a]1981 data based on 71 percent of estimated total nuclear-related employment universe.

Source: 1981 ERDA-601, preceeding BLS surveys, and INPO survey.

TABLE B-9. EMPLOYMENT IN THE NUCLEAR ENERGY FIELD BY INDUSTRIAL SEGMENT, 1981[a]

Industrial Segment	Employment GOCO	Private	Total
1	0	616	616
2	5,589	1,438	7,027
3	0	2,863	2,863
4	0	24,433	24,433
5	78	2,906	2,984
6	9	1,049	1,058
7	11,184	524	11,708
8	5,896	19,639	25,535
9	1,136	40,513	41,649
10	0	3,327	3,327
11	0	7,742	7,742
12	5,348	1,279	6,627
13	636	221	857
14	331	945	1,276
15	1,358	1,530	2,888
16	0	545	545
17	0	1,523	1,523
18	40,699	1,540	42,239
19	13,138	1,384	14,522
20	0	713	713
21	6,610	29,002	35,612
	92,012	143,732	235,744
Unknown	0	13,789	13,789
Total	92,012	157,521	249,533

Segment Definitions

1 URANIUM MILLING
2 PROCESSING AND ENRICHMENT OF REACTOR FUEL MATERIALS
3 PRODUCTION OF SPECIAL MATERIALS FOR USE IN REACTORS
4 REACTOR AND REACTOR COMPONENT DESIGN AND MANUFACTURING
5 FUEL FABRICATION
6 TRANSPORTATION OF NUCLEAR MATERIALS
7 CHEMICAL REPROCESSING AND DISPOSAL OF IRRADIATED MATERIALS
8 DESIGN AND ENGINEERING OF NUCLEAR FACILITIES
9 NUCLEAR REACTOR OPERATION AND MAINTENANCE
10 RADIOISOTOPES
11 DESIGN AND MANUFACTURE OF NUCLEAR INSTRUMENTS, GAUGES, AND CONTROL DEVICES
12 ACCELERATORS
13 ENVIRONMENTAL AND ECOLOGICAL RESEARCH AND EVALUATION
14 BIOLOGY AND MEDICAL RESEARCH
15 REACTOR RESEARCH, DEVELOPMENT, AND EVALUATION
16 COMMERCIAL LABORATORY SERVICES
17 HEALTH PHYSICS AND INDUSTRIAL SAFETY

TABLE B-9. (Continued)

18 WEAPONS DEVELOPMENT AND PRODUCTION
19 RESEARCH AND DEVELOPMENT IN NUCLEAR ENERGY
20 INDUSTRIAL RADIOGRAPHY
21 MISCELLANEOUS

[a] 1981 data based upon a 71 percent sample.

Source: ERDA-601.

TABLE B-10. STATE AND LOCAL GOVERNMENT RADIOLOGICAL HEALTH PERSONNEL, 1977-1979

	FY 1977	FY 1978	FY 1979
Technicians	76	88	113
All other	606	579	669
Total	682[a]	667[b]	782

[a]Two states not reported.

[b]Four states not reported.

Source: Department of Health and Human Services, Food and Drug Administration, *Report of State and Local Radiological Health Programs, Fiscal Year 1979* (Washington, D.C.: Department of Health and Human Services, 1980), p. 14.

TABLE B-11. NRC AND DOE NUCLEAR-RELATED EMPLOYMENT, 1981

Occupational Group	Nuclear Regulatory Commission	Department of Energy	Total
Managers	190	692	882
Engineers	1,159	608	1,767
Scientists	407	314	721
Technicians	12	68	80
All others	1,389	1,683	3,072
Total	3,157	3,365	6,522

Source: Unpublished DOE/NRC data.

TABLE B-12. EMPLOYMENT IN URANIUM MINING, 1970-1979

Year	Miners	All Other	Total
1970	2,341	2,087	4,428
1971	2,176	2,042	4,218
1972	1,937	1,784	3,721
1973	1,686	1,830	3,516
1974	1,977	1,951	3,928
1975	2,496	2,890	5,386
1976	3,077	4,015	7,092
1977	4,765	5,850	10,615
1978	5,192	6,879	12,071
1979	5,375	7,380	12,755
1980	4,767	7,001	11,768

Source: U.S. Atomic Energy Commission, *Statistical Data of the Uranium Industry* (Grand Junction Office, Colorado, 1970-1974); Energy Research and Development Administration, *Statistical Data of the Uranium Industry* (Grand Junction Office, Colorado, 1975); and U.S. Department of Energy, *Statistical Data of the Uranium Industry* (Grand Junction Office, Colorado, 1976-1981).

APPENDIX C
ERDA-601 SURVEY FORM

Oak Ridge Associated Universities for the Office of Light Water Reactors U.S. Department of Energy

A Survey of Occupational Employment in Nuclear or Nuclear Energy-Related Activities, 1981

The information collected on this form will be held in confidence and will be used for statistical purposes only by the U.S. Department of Energy.

This report is authorized by the Energy Reorganization Act of 1974, Public Law 93438. Your voluntary cooperation is needed to make the results of this survey comprehensive, accurate and timely.

Form Approved
O.M.B. No. 38R-0191

Collection Agency for the U.S. Department of Energy

(This request for information relates to:)

(Please change address or ZIP code if incorrect.)

General Instructions

A questionnaire is provided for each establishment of your organization which presumably is engaged in nuclear or nuclear energy-related activities.

This questionnaire should be completed for the reporting unit identified on the address label above.

In case your organization has *other* establishments engaged in nuclear or nuclear energy-related activities, an additional questionnaire which provides no reporting unit identification is enclosed. In such cases, enter the name and address of the establishment in the address label area as above.

Additional questionnaires or information may be obtained on request from Oak Ridge Associated Universities, P.O. Box 117, Oak Ridge, TN 37830 or by telephoning Area Code 615-576-3410.

Please complete the questionnaire and return it to us in the enclosed addressed envelope, which requires no postage. The second blank copy is for your files. ***PLEASE RETURN THIS QUESTIONNAIRE WITHIN 3 WEEKS.***

Person to be contacted if questions arise concerning this report:

Name and Title *(Please print or type.)*

Telephone *(Include Area Code.)*

1. Do you wish to receive a report on the findings of this survey? *(Check if yes.)* ☐

2. Scope of Survey

For the purpose of this survey, an establishment is considered to be in nuclear or nuclear energy-related activities if all or any part of the establishment is engaged in any of the activities listed in definition A on page 3. In most cases, an establishment is at a single physical location. This survey excludes mining and onsite facility construction (design and manufacture are included in the survey). On this basis – –

Were any employees of this reporting unit engaged in nuclear or nuclear energy-related activities as of:

April 15, 1981? Yes ☐ (21) No ☐ (22)

July 12, 1977? Yes ☐ (23) No ☐ (24)

July 12, 1975? Yes ☐ (25) No ☐ (26)

If you checked "Yes" as of April 15, 1981, please complete the remainder of the questionnaire.

If you checked "No", please return the questionnaire to avoid further correspondence.

3. Type of Establishment Identification *(Check one.)*

Type 1. Nonprofit Research Establishment ☐ (31)

Type 2. Private Industrial and/or Research Establishment ☐ (32)

Type 3. DOE-Owned Research Laboratory, Test Facility, and/or Production Facility ☐ (33)

4. Employment Summary

Data should relate to the payroll period including **April 15, 1981.**

		Employment
4.1	**Total Employment.** Enter the total number of employees of the establishment (both full- and part-time, salaried and hourly, production, maintenance, office-clerical, administrative, managerial, etc.). Include all personnel whether or not engaged in nuclear or nuclear energy-related activities. Exclude temporary employees hired under a sponsored summer student or comparable program. (99999)	
4.2	**Total Employment in Nuclear or Nuclear Energy-Related Activities.** Of the total number of employees reported above, how many were working in nuclear or nuclear energy-related activities? (Include a reasonable pro rata distribution of indirect employees of the establishment whose work is necessary to the conduct of nuclear or nuclear energy-related activities. Exclude persons working onsite in facility construction.) (88888)	

Remarks

ERDA-601 April 1981

6. Employment in Nuclear or Nuclear Energy-Related Activities by Industrial Segments

Distribute total employment in the Nuclear or Nuclear Energy-Related Activities (item 4.2) as of April 15, 1981, as follows:

Column 1 List each industrial segment (see definition A) in descending order of the number or proportion of employees in each segment as of April15, 1981. The principal segment of the establishment should appear on line 6.1.

Column 2 List the segment number for each activity shown in column 1. (See definition A.)

Columns 3 & 4 Distribute the total employment reported in item 4.2 by segment in column 3, if available. If employment data are not available, show a percentage distribution by segment in column 4 of the total employment reported in item 4.2. There should be an entry in either columns 3 or 4 for every segment shown in columns 1 and 2. The total of column 4, if used in lieu of column 3, should equal 100%.

	Industrial Segment Name	Industrial Segment No.	Distribution of Employees Engaged in Nuclear or Nuclear Energy-Related Activities	
			Number of Employees	Percent of Total
	(1)	(2)	(3)	(4)
6.1				
6.2				
6.3				
6.4			Total = Item 4.2	100%

*Principal nuclear or nuclear energy-related activity

Definitions for the Survey of Occupational Employment in Nuclear or Nuclear Energy-Related Activities

A. **Industrial Segments.** Nuclear or nuclear energy-related activities are comprised of the following industrial segments:

Code *Description*

1. **Uranium Milling:** Reduction of uranium ores to concentrates. **Excludes** mining.
2. **Processing and Enrichment of Reactor Fuel Materials:** Refining of reactor fuel concentrates and conversion of refined fuel concentrates and recovered U-235/U-238 to uranium hexafluoride, enrichment of these fuel materials in the isotope U-235, followed by conversion to oxides, carbides, or other fuel compositions.
3. **Production of Special Materials for Use in Reactors:** Preparation and treatment of core structural and cladding materials such as zirconium, control rod materials such as hafnium and boron, and moderators such as heavy water and graphite.
4. **Reactor and Reactor Component Design and Manufacturing:** The design and/or manufacture of nuclear reactors and reactor components, including control rods and drives for power, test, and research purposes and missile and space applications. Includes the assembly, testing, and disassembly of reactors and the testing of materials for reactor use.
5. **Fuel Fabrication:** Production of fuel forms (pellets, coated particles, etc.), and encapsulation of fuel fo ms in fuel assemblies.
6. **Transportation of Nuclear Materials:** Packaging and interfacility transportation of special nuclear materials, fabricated fuel assemblies, irradiated fuel assemblies, and other radioactive materials.
7. **Chemical Reprocessing and Disposal of Irradiated Materials:** Separation and recovery of fertile and fissile fuel materials, and of by-product materials. Includes purification, concentration, and packaging of fuel and by-product materials; storage and solidification of high-level wastes; collection, packaging, and disposal of low-level wastes.
8. **Design and Engineering of Nuclear Facilities:** Design and engineering of all nuclear facilities with the exception of those included in segments 4 (reactor and reactor components), 5 (fuel fabrication), 11 (nuclear instruments, gauges, and control devices), and 12 (accelerators). **Excludes** persons working onsite in facility construction.
9. **Nuclear Reactor Operation and Maintenance:** Operation and maintenance of nuclear power production, test, and research reactors. Includes operation and maintenance of auxiliary systems for supply and treatment of power, air, water, etc.
10. **Radioisotopes:** Manufacture, processing, and packaging of radioisotopes, including radiochemicals, radiopharmaceuticals, and other radioactive labeled compounds. Includes irradiation of medical supplies, food, and agricultural products, and of commercial materials. **Excludes** in-plant processing incidental to another activity.
11. **Design and Manufacture of Nuclear Instruments, Gauges, and Control Devices:** Design and manufacture of hot cell and laboratory instruments and monitoring and control devices, radiographic and teletherapy equipment, activation analysis systems, etc.
12. **Accelerators:** The design, engineering, manufacturing and/or construction, operation/maintenance, and research and development conducted for all classes of accelerators.
13. **Environmental and Ecological Research and Evaluation:** Activities to preserve, improve, or restore the natural environmental and ecological balance. Types of activities covered are thermal effects and effects of irradiation on plants, animals, and marine life.
14. **Biology and Medical Research:** Research on the interaction of radiation with biological systems; use of radiation and radioisotopes in diagnosis and treatment of illnesses; study of effects of low-level radiation and ingestion of toxic and radioactive materials on biological systems.
15. **Reactor Research, Development, and Evaluation:** Activities relating to research, development, and demonstration of new fission reactor systems, components, fuels, moderators, etc. Includes development, conduct, evaluation, and analysis of reactor safety tests.
16. **Commercial Laboratory Services:** Provides laboratory service activities for other establishments. Examples of services are activation analysis, film badge service, mass spectrometry, radiography, and physical testing.
17. **Health Physics and Industrial Safety:** Establishes, evaluates, and monitors working conditions for compliance with industrial safety and radiation exposure standards.
18. **Weapons Development and Production:** Develops, designs, tests, and fabricates nuclear weapons.
19. **Research and Development in Nuclear Energy:** Investigations directed toward the development of new or fuller scientific knowledge of the subject. It also covers systematic application of scientific knowledge directed toward the creation of new or substantially improved processes, procedures, techniques, etc. It **excludes** research and development reported under segments 12, 13, 14, and 15, which are to be reported separately.
20. **Industrial Radiography:** Commercial radiographic services. **Excludes** in-plant radiography where its use is incidental to another activity.
21. **Miscellaneous:** Activities not classified in any of the above segments, such as consultant services, laundry services, and leasing services.

Definitions for the Survey of Occupational Employment in Nuclear or Nuclear Energy-Related Activities—*Continued*

B. Occupational Definitions

Employees in the specialized occupations covered by this survey should be counted on a "Working As" basis, as of the date of the report (April 15, 1981) regardless of field of degree or whether they hold a college degree. For example, an employee trained as an Engineer but working as a Mathematician as of the date of the report should be reported as a Mathematician. Similarly, an employee trained as a Life Science Technician but working as a Health Physics Technician as of the date of the report should be reported as a Health Physics Technician. Include all employees in research and development, production, management, technical service, sales, and other positions which require them to use the indicated level of knowledge in their work. Exclude persons working onsite in facility construction.

Managers (Occ. Code 10000): Include persons concerned with policymaking, planning, organizing, staffing, directing, and/or controlling activities that are common to many types of organizations, usually through subordinate supervisors who directly supervise the activities of the company or establishment work force and/or professional or technical management.

Engineers (Occ. Code 21000): Count all persons actually engaged in engineering work at a level which requires knowledge of engineering equivalent at least to that acquired through completion of a 4-year college course, regardless of whether they hold a college degree. Exclude persons trained in engineering, but currently employed in positions not requiring the use of such training.

Nuclear and Reactor Engineers (Occ. Code 21015): Count all engineers who are concerned with the release, control, and use of all types of energy from nuclear sources, including the design and development of fission or fusion reactors for the controlled release of nuclear energy, and the applications of radiation. Exclude Nuclear Reactor Operators.

Mathematicians (Occ. Code 22100): Count only those persons whose positions require a knowledge of mathematics equivalent at least to that acquired through a 4-year college course with a major in mathematics and who spend the greatest proportion of their time in development or application of mathematical techniques, regardless of whether they hold a college degree. Include Actuaries, Statisticians, and Computer Programmers only if they specialize in mathematical techniques. Exclude Accountants.

Physical and Earth Scientists (Occ. Code 22200): Count all Chemists, Physicists, Metallurgists, Geologists, Geophysicists, and other Physical and Earth Scientists who are actually engaged in scientific work at a level which requires a knowledge of the physical sciences equivalent to that acquired through completion of a 4-year college course with a major in one of the physical sciences, regardless of whether they hold a college degree. Exclude persons trained in the physical sciences but currently employed in positions not requiring the use of such training.

Life Scientists (Occ. Code 22300): Count all Health Physicists, Medical Scientists, Agricultural Scientists, Biological Scientists, and other Life Scientists who are actually engaged in scientific work at a level which requires a knowledge of the life sciences equivalent to that acquired through completion of a 4-year college course with a major in one of the life science fields, regardless of whether they hold a college degree. Exclude persons trained in the life sciences but currently employed in positions not requiring the use of such training. Exclude Psychologists. See definitions for Health Physicists and Biological Scientists.

Biological Scientists (Occ. Code 22303): Count all persons who meet the general requirements for "Life Scientists" and who spend the greatest proportion of their time in scientific work dealing with life processes other than those classified in the agricultural and medical sciences. Include Pathologists, Microbiologists, Pharmacologists, Toxicologists, Botanists, Zoologists, etc.

Medical Scientists (Occ. Code 22305): Count only those Physicians, Dentists, Public Health Specialists, Pharmacists, and members of other scientific professions who meet the general requirements for "Life Scientists" and who are concerned with the understanding of human diseases and improvements of human health, and spend the greatest proportion of their time in clinical or laboratory investigation or other research, production, technical writing, and related activities. Exclude from this category all practitioners -- that is, those Medical Scientists who spend the greatest proportion of their time providing care to patients, dispensing drugs or services, or in diagnosis, etc. Persons working as Pathologists, Microbiologists, Pharmacologists, etc., should be excluded from the figures for Medical Scientists and included in the figures for Biological Scientists.

Health Physicists (Occ. Code 22307): Count all persons who meet the general requirements for "Life Scientists or Engineers" and who are concerned with programs to protect plant and laboratory personnel from radiation hazards; develop inspection standards, radiation exposure limits, and decontamination procedures, conduct tests to insure that radiation is not in excess of permissible limits; and design or modify such health physics equipment as detectors and counters to improve radiation protection.

All Other Professional Workers (Occ. Code 29000): Include all other workers concerned with such fields as law, education, labor, and business relations requiring a substantial educational preparation, usually at the university level.

Technicians (Occ. Code 30000): Count all persons actually engaged in technical work at a level which requires knowledge of engineering, mathematical, and physical or life sciences, comparable to that acquired either through study at technical institutes, junior colleges, or other formal post-high school training less extensive than a 4-year college course or through equivalent on-the-job training or experience. Some typical job titles are Draftsman, Surveyor, Laboratory Assistant, Physical Science Aide, and Electronic Technician. All persons in positions that require the indicated level of knowledge should be counted, regardless of job title or department in which employed. **Computer Programmers** who meet the above definition of Technicians should be reported under "All Other Technicians," Occupation Code 30000. Exclude those persons whose positions require knowledge of training consistent with the foregoing definitions of Engineers, Mathematicians, or Scientists, and report them in the appropriate occupational category on the questionnaire. Also, exclude all craftsmen such as Machinists and Electricians.

Nuclear Reactor Operators (Occ. Codes 34040, 34060, 34061): Count all persons who spend the greatest proportion of their time in (a) the actual manipulation of the controls of a nuclear reactor, or (b) directing others in the manipulation of such controls. Under Nuclear Regulatory Commission (NRC) licensing regulations, the former are referred to as "operators" and the latter as "senior operators." Count as "auxiliary operators," those persons who are not licensed operators but work under the supervision of either nuclear or senior operators while preparing to fulfill NRC requirements to become licensed operators. A nuclear reactor is an apparatus, other than a nuclear weapon, designed or used to sustain nuclear fission and self-supporting chain reaction (e.g., power reactors, test reactors, production reactors, research reactors, critical assemblies). Exclude persons who spend the greatest proportion of their time as Nuclear Reactor Engineers or in performing other functions of a professional, scientific, or engineering nature.

Welders with Nuclear Certification (Occ. Code 58015): Count all persons certified under NRC requirements who join surfaces, or otherwise make or repair structures or parts, using gas or electric welding, soldering, or brazing equipment with or without filler material; who fuse to join or shape leaf products or parts, using a gas torch; who cut or perforate metal, using gas or electric welding equipment.

All Other Skilled Crafts and Kindred Workers (Instrument Repairer, Painter, Maintenance, Patternmaker, Metal Die Setter, Die Sinker, Etc.) Exclude persons working onsite in facility construction. (Occ. Code 59001): Include all other skilled crafts and kindred workers in production, maintenance, repair, power plant, and material handling occupations that predominantly require a thorough and comprehensive knowledge of processes involved in the work, the exercise of considerable independent judgment, usually a high degree of manual dexterity, and in some instances, extensive responsibility for valuable product or equipment. Workers in these occupations usually become qualified by serving apprenticeships or completing extensive training periods. **Occupations should be counted as skilled if the specific vocational preparation required to perform them involves training or other preparation of two years or more.**

Clerical Workers (Occ. Code 50000): Include office and plant clerical personnel. **Office clerical** work involves preparing, transcribing, transferring, systematizing, and preserving communications and records; collating accounts, and distributing information. Typical examples are Secretaries, Stenographers, Typists, File Clerks, Office Machine Operators, Bookkeepers, Cashiers, Mail Clerks, and Telephone Operators. **Plant clerical** work involves planning, coordinating or expediting of production and the flow of work; or the clerical aspects of receiving, storing, issuing, or shipping of materials, merchandise, supplies, or equipment.

All Other Workers (Occ. Code 59999): Include service and sales workers, operatives, laborers, and all other workers not classified above. Exclude persons working onsite in facility construction.

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